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PART 6.

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TRANSACTIONS OF THE SOCIETY FOR BRITISH ENTOMOLOGY

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PART 6.

THE OCCURRENCE OF SPERMATOPHORES AND THEIR MEASUREMENTS IN SOME BRITISH LEPIDOPTERA.

By

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(University of Pennsylvania and Lincoln University, Pennsylvania).

There is much information in the literature on the classification of the Lepidoptera, but though some studies have been made of the external genitalia of this order of insects chiefly as a means of classification, there is little published information on the internal genitalia. Our knowledge would be enriched if more experimental investigation were made in this field of research. There are conflicting reports concerning parthenogenesis among various groups of this order and recent investigations confirm more than one mating during the life of the female. Some species (*Malacosoma americana* Fb.) mate only once during the life of the female, and others (*Ephestia kuehniella* Zell.) may mate as many as five times. In the latter species five spermatophores can sometimes be observed in the bursa copulatrix (fig. 4). At this point some interesting questions arise. What causes the empty spermatophores to be pushed up to the top of some types of bursae and apparently dissolved? Can this be done by the gelatinous secretion found in some cases at the top of this organ? (fig. 1, s). What is it that controls the flow of the seminal fluid through the female reproductive system and directs it to the proper place, which is the seminal receptacle, after it leaves the bursa? (fig. 5, E and L). What prevents it from escaping through the many openings of the female system and thus going to the wrong destination? Recent unpublished investigations show that no spermatophores as they generally

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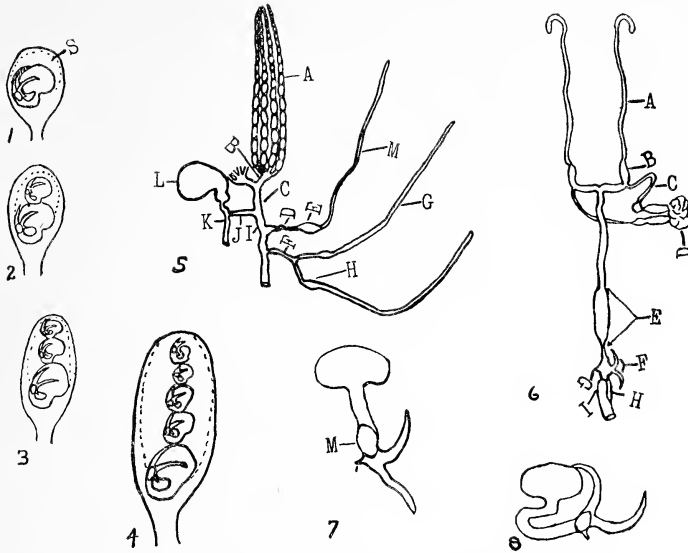
appear can be found in the bursa of some species after mating. If they are present they must be modified so that they appear different from the general types.

It was this latter peculiarity together with the above questions that led me to undertake this investigation, the object of which is to study the bursal content of all wild females collected. Generally, though not always, the presence of a spermatophore in the bursa renders the female fertile. It is agreed that full spermatophores may vary in size in the same species and that the presence of one does not necessarily mean that the female is fertile, though it does indicate that the female has mated. Often empty spermatophores are observed, their contents having been used. The presence of one spermatophore, if the behaviour is the same as in *Ephestia kuehniella*, indicates that the female has mated once, if two are present twice, and so on (figs. 1, 2, 3 and 4).

I wish to thank Mr. W. Fassnidge for identifying these insects and for reading the MS. I am also grateful to Prof. W. Rae Sherriffs of University College, Southampton, England, in whose laboratory this investigation was carried out, for his many kindnesses. I also wish to express my appreciation to President W. L. Wright of Lincoln University, Pennsylvania, who helped me to make this visit to England. I am indebted to Dr. Philip P. Calvert, the editor of *Entomological News*, for permission to reproduce the figures of *Ephestia kuehniella* Zeller.

MATERIAL AND METHOD.

The material consisted of female moths and butterflies collected in the neighbourhood of Southampton in 1939. They were obtained by the ordinary methods of field hunting and by means of a light trap. The light trap consisted of two cones, a small one at the top and a larger one at the bottom, made of tin with a bright surface. The small cone had a diameter of 8.5 inches at the bottom and 1.25 inches at the top, and was 5.5 inches deep. The diameter of the larger cone was 14 inches at the top and 3.5 inches at the bottom, being 10.75 inches deep. An ordinary light socket was fitted into the top aperture of the smaller cone, and was suspended from a metal plate attached to a long wooden pole. A non-frosted 100-watt bulb was used with reasonable success; stronger bulbs with this type of trap gave more satisfactory results in the past. The large cone was suspended from the metal plate by means of four iron wires and was arranged so that it was from three to four inches below the smaller cone. At the bottom was a cylindrical trap made of lace curtain material, eleven inches long. A large cylindrical sac, made of cheese cloth, was suspended from the top edge of the larger cone, and could be opened or closed by means of a string.



THE REPRODUCTIVE ORGANS AND SPERMATOPHORES OF
Ephestia kuehniella ZELL.

Fig. 1.—Bursal cavity with one spermatophore as the result of one mating (s, secretion in the bursa). Fig. 2.—Bursal cavity with two spermatophores as the result of two matings. Fig. 3.—Bursal cavity with three spermatophores as the result of three matings. Fig. 4.—Bursal cavity with five spermatophores as the result of five matings. Fig. 5.—Female reproductive organs (A, ovary; B, oviduct; c, common oviduct; d, duct of the seminal receptacle; E, seminal receptacle; F, duct of the accessory glands; G, accessory gland; H, vesicle of the accessory gland; I, vagina; J, seminal duct; K, duct of the bursa; L, cavity of the bursa; M, gland of the seminal receptacle). Fig. 6.—Male reproductive organs (A, accessory gland; B, seminal vesicle; c, vas deferens; D, testes; E, ejaculatory duct; F, long hooks in which the long hooks of the spermatophore are moulded; G, small hook in which the small hook of the spermatophore is moulded; H, penial groove; I, penis). Fig. 7.—A spermatophore as it appears in contact with the seminal duct (M, opening in the neck). Fig. 8.—A spermatophore as it appears in the upper part of the bursa.

(Note.—All drawings have been made with the aid of a camera lucida, and are to the same scale.)

The apparatus was suspended from a window of the Avon Fishery Laboratory, situated at the back of South Stoneham House, one of the Halls of Residence for men students of the College. It was lighted at about 10 p.m. (summer time), and in the mornings the insects were collected from the sac. This type of light trap may have its drawbacks, but most of the moths taken were in very good condition. Sometimes undesired insects such as grasshoppers batter the wings of some moths and so damage them.

The insects were killed by cyanide and dissected in physiological salt solution. The dissection was done by removing the abdomen from the body near the thorax, placing it in a dissecting dish and cutting along the side nearly to the end. The contents were removed with the aid of tweezers and a fine needle. The bursa copulatrix was carefully removed from the mass after noting its relationship to the seminal duct, and its contents were removed and studied. This operation was performed on a slip in the case of small Lepidoptera. An ordinary thin celluloid rule divided into millimetres was used in measuring the spermatophores. The dissections and measurements were made under the binocular dissecting microscope.

OBSERVATIONS.

***Pieris rapae* L.**

(fig. 9, A and B).

The bursa copulatrix consists of a large cavity with a short duct extending from the top of it into a small cavity. The large cavity contains the head of the spermatophore, and a well developed lamina dentata is situated in its walls (fig. 9, Ax). A secretion fills the small cavity. The neck of the spermatophore extends from the head to the seminal duct. This type of bursa has been found in all sulphur butterflies and in the native American cabbage butterfly.

***Argynnis cydippe* L.**

(fig. 9, c).

The bursa is dumb-bell-shaped with the seminal duct extending from the upper part of the lower cavity of the dumb-bell. Both cavities and the neck of the dumb-bell contain a secretion which completely surrounds the spermatophore. The head measures 2 mm. across its long axis and the greatest diameter across its short axis is 1 mm. The neck is 2.1 mm. long. Females were caught in the New Forest near Brockenhurst, Hants, on July 15th.

***Maniola jurtina* L.**

(fig. 9, F and G).

The bursa is of the simple type with the seminal duct extending from a point near the base of the bursal duct. The head of the spermatophore is situated in the cavity of the bursa and its neck extends to the seminal duct. The head measures 1.5 mm. across its long axis and 1 mm. across the greatest diameter of its short axis. The neck is 2 mm. long. Females were caught in the New Forest near Brockenhurst, July 15th.

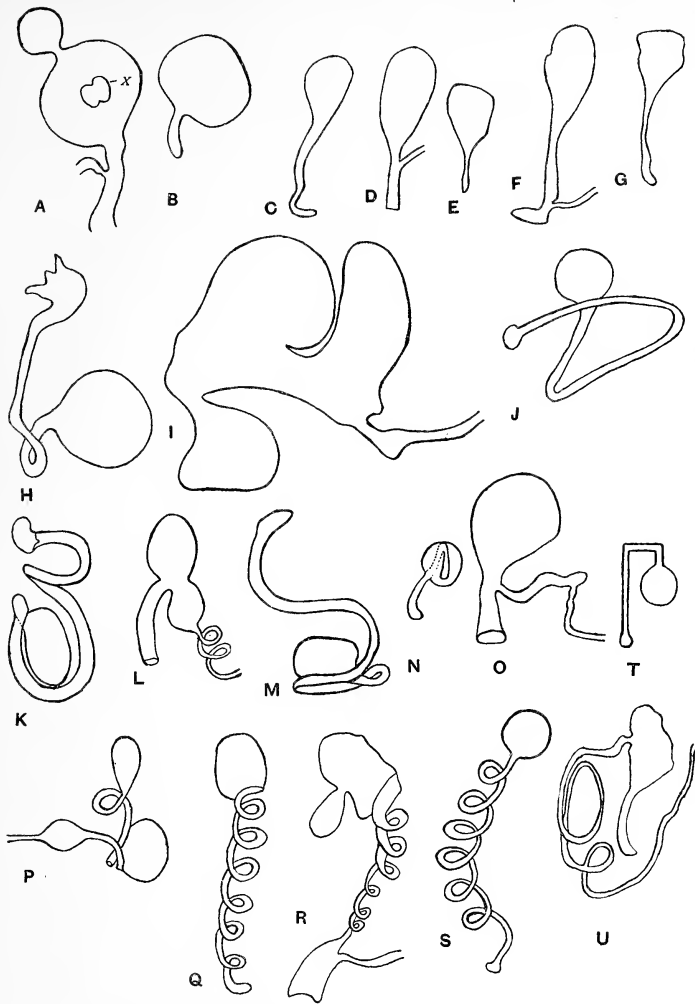


Fig. 9.—The bursa copulatrix and spermatophores of some British Lepidoptera. A, bursa and part of seminal duct of *Pieris rapae* L. (x, Lamina dentata); B, spermatophore of *Pieris rapae* L.; C, spermatophore of *Argynnis cydippe* L.; D, bursa and part of seminal duct of *Aphantopus hyperanthus* L.; E, spermatophore of *Aphantopus hyperanthus* L.; F, bursa and part of seminal duct of *Maniola jurtina* L.; G, spermatophore of *Maniola jurtina* L.; H, spermatophore of *Diacrisia lutea* Hufn. (= *lubricipeda* L.); I, bursa and part of seminal duct of *Diacrisia lutea* Hufn. (= *lubricipeda* L.); J, spermatophore of *Agrotis putris* L.; K, spermatophore of *Barathra brassicae* L.; L, bursa and part of seminal duct of *Parastichtis monoglypha* Hufn.; M, spermatophore of *Parastichtis monoglypha* Hufn.; N, spermatophore of *Ematurga atomaria* L.; O, bursa and part of seminal duct of *Eupithecia vulgata* Haw.; P, bursa and part of seminal duct of *Sterrha trigeminata* Haw.; Q, spermatophore of *Eurrhypara urticata* L.; R, bursa and part of seminal duct of *Eurrhypara urticata* L.; S, spermatophore of *Borkhausenia pseudospretella* Stt.; T, spermatophore of *Laodamia fusca* Haw.; U, bursa and less than one half of seminal duct of *Sterrha aversata* L.

Aphantopus hyperanthus L.

(fig. 9, D and E).

The bursa is of the simple type with the seminal duct extending from a point near the upper end of the bursal duct. The head of the spermatophore is situated in the cavity of the bursa and its neck extends to the seminal duct. The head measures 2 mm. across its long axis and 1 mm. across the greatest diameter of its short axis. The length of the neck is 1 mm. Females were caught in the New Forest near Brockenhurst, July 15th.

Tyria jacobaeae L.

The bursa is composed of two bulbous cavities. The first cavity contains the head of the spermatophore. The second, into which extends the neck of the spermatophore, also contains a creamy white secretion. These two cavities are connected by a large duct through which extends the neck of the spermatophore. Only one spermatophore was observed in the bursa copulatrix. Its head measured 1.5 mm. across its long axis and 1 mm. across its short axis. The neck was 4 mm. long. These females were captured in a field near Swaythling, Hants, on June 8th, and others have been caught in the light trap.

Diacrisia lutea Hufn. (=lubricipeda L.).

(fig. 9, H and I).

The bursa copulatrix consists of a large cavity and a small one joined by a large duct (fig. 9, I). The large cavity contains the head of the spermatophore, and the neck extends through the duct, after forming a coil, into the small cavity which contains a secretion. The seminal duct extends from the bottom of the small cavity to the vagina. One spermatophore was observed and its head measured 1.1 mm. across its long axis and 1 mm. across its short axis. The length of the neck extended was 7.1 mm. (fig. 9, H). These insects were obtained from a field near Swaythling, on June 8th.

Euxoa segetum Schiff.

The bursa copulatrix is U-shaped with one arm containing the head of the spermatophore larger in diameter than the other arm. The necks of the spermatophores extend through the coils of the slender arm to the seminal duct, which is situated at the top. The heads of the spermatophores are vase-shaped and measure 5 mm. across their long axes, 2 mm. at the top, and 1 mm. at the lower end across their short axes. Four spermatophores have been found in the bursa of some females. The full one always occupies the entrance to the seminal duct. Females were caught at various times in the light trap during June.

Feltia exclamationis L.

The bursa is U-shaped with the bursal duct extending from the closed end of the U. One arm is shorter than the other and contains the head of the spermatophore. The neck extends from the head to the seminal duct, which is situated at the top of the longer coiled arm. The head measures 2 mm. across its long axis and 1 mm. across its short axis. The neck is 2.4 cm. long. The bursa copulatrix of many females contained two spermatophores. Whenever this was the case, the terminal end of the empty spermatophore was bent away from the seminal duct. The terminal end of the full spermatophore always occupies this position. Many females were caught in the light trap on June 9th, 10th and 11th.

Agrotis putris L.

(fig. 9, j).

The bursa is of a simple type somewhat similar to that of *Ephestia kuehniella* Zell., but has a small reservoir from which the seminal duct extends to the vagina. The neck of the spermatophore is bent to form a triangle, but one side extends beyond the triangle to open into the reservoir. The spherical head measures 1.3 mm. in diameter, and the neck when straight measures 1.21 cm. in length. Insects were captured near Southampton, on June 10th.

Barathra brassicae L.

(fig. 9, k).

The bursa is composed of two chambers, a large one which contains the head of the spermatophore and a small one into which its neck opens. The seminal duct extends from the small chamber to the vagina. The head of the full spermatophore is 2 mm. across its long axis and 1 mm. across the greatest diameter of its short axis. The neck when straight is 12 mm. long. Of the females dissected some had two spermatophores, which indicated that these females must have mated twice, while others had only one. These females were caught in the light trap on the night of June 11th.

Miselia oleracea L.

The bursa is composed of a large cavity connected with a small one by a large duct. The head of the spermatophore is situated in the large cavity and is surrounded by a gelatinous secretion. The neck opens into the small cavity, which is filled with secretion. The seminal duct extends from the small cavity to the vagina. Two spermatophores have been found in the

bursa of some females. The head measures 3 mm. across its long axis and 2 mm. across its short axis. The length of the neck extended is 1.2 cm. Many of these insects were caught in the light trap during June and early July.

Parastichtis monoglypha Hufn.

(fig. 9, L and M).

The bursa copulatrix consists of two cavities, a large one which contains the head of the spermatophore, and a small one filled with secretion into which extends the neck of the spermatophore. The spermatophore resembles an S. Its head measures 2.1 mm. across its long axis and 2 mm. across its short axis. The length of the neck is 1.3 cm. Many of these insects were trapped during June.

Procus strigilis Cl.

The bursa is of the simple type but has a small reservoir near its base from which extends the seminal duct to the vagina. Two spermatophores have been found in some females. The neck of the spermatophore is coiled once and extends into the reservoir. The head measures 1 mm. across its long axis and 0.9 mm. across its short axis. The length of the neck is 5 mm. Insects were caught in the light trap in June and July.

Trigonophora meticulosa L.

The bursa copulatrix is U-shaped with the bursal duct extending from the closed end. One arm has a larger diameter than the other and contains the heads of the spermatophores. The other arm is longer and coiled many times. The necks of the spermatophores extend through these coils to the seminal duct which is situated at the top of the arm. As many as three spermatophores have been found in the bursa of some females. The full one always occupies the entrance to the seminal duct. The head of the spermatophore measures 2.5 mm. long and 3 mm. across its diameter. The length of the neck extended is 3.5 cm. A few of these insects were trapped from time to time during June.

Ematurga atomaria L.

(fig. 9, N).

The bursa copulatrix is of a simple type and the seminal duct is situated near its base. The neck of the spermatophore is bent like a crescent around the spherical head and extends to the seminal duct. The diameter of the head is 1 mm. and the neck when straight is 3 mm. long. Insects were captured near Southampton on June 10th.

Xanthorrhoe montanata Schiff.

The spermatophore is situated in the bursal cavity. Another cavity surrounds the bursal duct. The seminal duct extends from the base of the bursal cavity to the vagina. The diameter of the head of the spermatophore measures 1.1 mm. The length of the neck is between 0.2 and 0.3 mm. Many insects were trapped during June.

Epirrhoe alternata Müller (= *sociata* Bork.).

The bursa is of the simple *Ephestia kuehniella* Zell. type except for a small reservoir near its base. The seminal duct extends from the reservoir to the vagina. The neck of the spermatophore extends below the reservoir, but is bent so that its open end opens into this reservoir. The head of the spermatophore is spherical and its diameter measures 1.1 mm. The neck is 2 mm. long. These insects were caught in a field near Swaythling, on June 8th.

Eupithecia venosata Fb.

The bursa copulatrix consists of an inner sac which is surrounded by a larger outer one. A clear secretion was found between the outer walls of the inner sac and the inner walls of the outer sac. The inner sac is covered with brown chitinous teeth and contains the spermatophore, which is spherical and measures 0.5 mm. in diameter. The length of its neck is between 0.5 and 0.6 mm. Females were captured in a field near Southampton, on June 10th.

Eupithecia vulgata Haw.

The bursa copulatrix consists of a large cavity with a tubular projection extending from its base. The cavity is covered with brown chitinous teeth except near the point where it joins the bursal duct. The seminal duct extends from the distal end of the tubular projection to the vagina. Two of these females were observed, but no typical spermatophore was found; however, the saccular part contained a secretion which ran out when it was punctured and hardened into a stiff mass. The contents of the bursae make it appear that these females were fertile even if no typical spermatophores were observed (fig. 9, o). These insects were obtained from a field near Swaythling, on June 8th.

Gymnoscelis pumilata Hb.

This species has a small simple bursa, the saccular part of which is half covered with chitinous teeth. Typical spermatophores have been found in these females, but they were too small for accurate measurement. Insects were caught in the light trap in June and early July.

Timandra amata L.

The bursa has a short chitinous duct extending from its sac. A reservoir is present from which the seminal duct extends to the vagina. Two spermatophores have been observed in this species. The heads of full ones measure 1 mm. across the long axis and 0.5 mm. across the short axis. The neck was 1.1 mm. long. Female specimens were trapped on June 10th.

Sterrha trigeminata Haw.

(fig. 9, p).

The bursa consists of two cavities, one into which extends the bursal duct and one at the base of this duct. The lower cavity was filled with secretion and the seminal duct extended from it. The seminal duct expands into a bulb between the lower cavity and the vagina. The upper sac was full of secretion containing sperm, but no typical spermatophore was observed. Two females were caught in Mr. Fassnidge's garden at the end of June.

Sterrha aversata L.

(fig. 9, v).

The bursa consists of an outer sac which surrounds an inner one. The inner sac is covered with chitinous teeth. Only one female was obtained, but the most striking thing observed is the long seminal duct, which is coiled many times. No spermatophore was found in the bursa and this female was probably virgin. The length of the bursa including its duct across its long axis is 4 mm. The diameter of the sac is 1 mm. The length of the seminal duct is 7.5 cm. This moth was caught in the light trap during June.

Laodamia fusca Haw.

The reproductive organs resemble those of *Ephestia kuehniella* Zell. Six females were observed and the bursa copulatrix of each contained a spermatophore. In four of these the head of the spermatophore was ruptured, probably by the lamina dentata. The head measures between 0.8 and 0.9 mm. across the long axis and 0.6 mm. across the short axis. The neck of the spermatophore is twice bent near the head, forming two right angles (fig. 9, r). These insects were captured from burnt gorse stems near Southampton, on June 8th.

Crambus pascuellus L.

The bursa is of the simple type with a slender duct. The head of the spermatophore is spherical with a short twisted neck. The diameter of the head is 1 mm. and the length of the

neck is 1 mm. These insects were captured near Southampton, on June 10th, and have also been caught in the light trap.

Eurrhypara urticata L.

(fig. 9, ♀ and ♂).

The bursa consists of a large cavity with a small one extending from its side. The bursal duct is coiled six or seven times, and through it extends the neck of the spermatophore to the seminal duct below. The upper coils are larger than the lower ones. The large cavity contains the head of the spermatophore and a secretion fills the smaller one. The head of the spermatophore measures 1.4 mm. across its long axis and 1.1 mm. across its short axis. The neck of the spermatophore when straight is 8 mm. long. Females were caught in the light trap in early July.

Scoparia ambigualis Tr.

The bursa is of a simple type similar to that of *Ephestia kuehniella* Zell. Two spermatophores were observed in some females with the empty one at the top and the full one at the lower part of the bursa. Other females had only one. The head of the full spermatophore measures 0.8 mm. across the long axis and 1 mm. across the short axis. The neck is very slender and measures 1.6 cm. in length. These insects were captured in a field near Southampton, on June 10th.

Tortrix viridana L.

The bursa is similar to that of *Ephestia kuehniella* Zell. Three females were dissected and the bursae of two were transparent, the insect being probably virgin. The third female was found *in cop.* at 5.05 p.m., and the pair was put into a collecting box and observed until they separated at 6 p.m. The female was dissected and a spermatophore was found in the bursa copulatrix. Its head measures 1 mm. across the long axis and 0.8 mm. across the short axis. The length of the neck is 1.3 mm. These insects were beaten from an oak tree near Southampton, in June, and the species was also caught in the light trap.

Borkhausenia pseudosporetella Stt.

(fig. 9, s).

The bursa copulatrix is coiled into six or seven coils and resembles a corkscrew. The lower coils are larger than the top ones. There is a cavity at the top of the coils with a lamina dentata, which contains the head of the spermatophore. The neck extends from the head through the coils to the seminal duct situated at the base of the bursa. The head measures 0.6 mm. across its long axis and 0.5 mm. across its short axis.

The length of the neck when extended is 3.5 mm. Great care must be exercised to remove the spermatophore from the bursa. Several females were obtained from Mr. Fassnidge's breeding cages.

CONCLUSIONS AND SUMMARY.

1. The object was to study the occurrence and to measure the spermatophores found in the bursa copulatrix of various female Lepidoptera. The material was collected in the field and by means of a light trap. The abdomens were removed near the thorax and the dissections were made in physiological salt solution.

2. The spermatophores of the species described make it clear that the terminal portions of the male reproductive organs vary little among different species of this order.

3. The presence of a spermatophore in the bursa copulatrix indicates that the female has mated once; and when more than one is present each one indicates a different mating if the mating behaviour is the same as in *Ephestia kuehniella* Zell.

4. Even in the most complicated bursa the open end of the spermatophore is always nearest the seminal duct which leads to the vagina. In some species, however, the open end opens into a reservoir or cavity, from which arises the seminal duct. In the latter case, if it discharges into a cavity, this cavity is usually filled with a secretion.

5. The description of the bursae given in this paper makes it clear that the female reproductive organs have undergone greater changes than those of the male, and this is a good index to the relationship of various species.

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